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PAPER 42-3

MARBLE MOUNTAIN MAP-AREA
ALBERTA

By

H. H. Beach

OTTAWA
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(Summary Account)

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Illustration

Marble Mountain Map-area, Alberta

INTRODUCTION

Marble Mountain map-area lies between Red Deer and Clearwater Rivers. The eastern boundary is approximately 38 miles west of Olds on the Calgary-Edmonton highway. A motor road follows the north side of Clearwater River through the northwest corner of the map-area and a poorly travelled road follows James River to the mouth of Willson Creek.

Capable assistance in the field was given by Messrs. F. A. McKinnon, D. S. Kirkwood, and R. E. Urton.

STRATIGRAPHY

Strata ranging in age from Carboniferous to Tertiary outcrop within the map-area. Some knowledge of the pre-Carboniferous strata underlying the area was gained through study of drill samples from Altoba Clearwater No. 1 well, on the south bank of Clearwater River about 1 mile west of the western boundary of the map-area.

The following table indicates the succession of strata outcropping in the map-area and the pre-Carboniferous strata penetrated in Altoba Clearwater No. 1 well. The well started in the Banff formation, 239 feet above the base, and reached a depth of 3,035 feet in pre-Devonian (possibly Cambrian) strata.

Table of Formations

Age	Formation	Character	Thickness
Recent and Pleistocene		River gravels Glacial drift	Feet
Erosional unconformity			
Tertiary	Paskapoo	Buff weathering sandstone; brown and green shale; carbonaceous shale	3,000+
Erosional unconformity			

Age	Formation	Character	Thickness
			Feet
Upper Cretaceous	Edmonton	Soft, light grey and brown sandstone; light and dark green, crumbly shale; dark, carbonaceous shale; pebble and cobble conglomerate; bentonite; coal	3,800±
	Erosional unconformity		
	Brazeau (Belly River)	Greenish grey sandstone; green shale; carbonaceous shale; pebble conglomerate; minor bentonite	1,080-1,500
	Wapiabi	Nodular, sandy shale; platy shale; thin limestone beds; minor sandstone	1,500-1,600
	Bighorn (Cardium)	Thin-bedded, dark grey, quartzitic sandstone; rusty, sandy shale; pebble conglomerate	225-250
	Blackstone	Black shale; platy, sandy shale and thin sandstone beds	800-1,050
Lower Cretaceous	Blairmore	Upper part: greenish grey sandstone; green and maroon shale; pebble conglomerate Lower part: grey, quartzitic sandstone; brown sandstone; carbonaceous shale; pebble conglomerate; thin limestone beds	1,500±
Erosional unconformity			

Age	Formation	Character	Thickness
			Feet
Jurassic	Fernie (may include some Kootenay beds)	Black, fissile shale passing upward into rusty brown weathering, fine-grained sandstone alternating with dark carbonaceous shale; a 4-inch coal seam occurs 50 feet below the top	200
Triassic	Spray River	Dark, cherty and arenaceous limestone; platy and argillaceous limestone; black, phosphatic limestone	70-105
	Erosional unconformity (?)		
Pennsylvanian ?	Rocky Mountain	Rose weathering, light grey, dolomitic quartzite; porous, black, quartzitic sandstone at the base	10-12
	Erosional unconformity		
Lower and Middle Mississippian	Rundle	Light grey, coarse-grained, and dark grey, fine-grained limestone; arenaceous dolomite; dolomite breccia; oolitic limestone	700-720
Lower Mississippian	Banff	Dark grey to black, nodular limestone; shaly limestone; calcareous shale	700-800
			Drilling depths in Altoba-Clearwater No. 1 well
	Exshaw	Black, non-calcareous shale	259 to 262 (3)[1]

Age	Formation	Character	Thickness
			Feet
Devonian		Largely finely crystalline, dark grey dolomite with 35 feet of black, fine-grained limestone at the top	262-1,185 (923)
		Fine-grained, black, argillaceous limestone with 100 feet of coarse-grained, light grey dolomite at the top; limestone pebble conglomerate at base	1,186-2,066 (880)
		Fine-grained, dark grey, argillaceous limestone grading upward into black, slightly calcareous shale above 2,169 feet	2,067-2,232 (165)
		Dark grey, fine-grained, argillaceous limestone	2,233-2,349 (116)
		Grey-brown and light grey, coarse-grained dolomite, and fine-grained, dark grey dolomite; black, shaly limestone at base	2,350-2,720 (370)
		Erosional unconformity (?)	
Pre-Devonian		Light grey and maroon quartzite with minor argillite and conglomerate	2,721-2,795 (74)
		Grey, oolitic limestone, interbedded with grey argillite; conglomeratic at the top	2,796-3,035 (239)

[1] Figures in brackets are drilled thicknesses and, because of the dip of the strata, may exceed the true thicknesses by as much as 10 or 15 per cent.

NOTES ON FORMATIONS

All the formations outcropping within the map-area are widespread throughout the Foothills belt, and their general characteristics are well known. The following notes emphasize only those features that are particularly characteristic of the formations as they are represented within this map-area.

Banff Formation

The Banff formation is estimated to be 700 to 800 feet thick. The basal 259 feet, consisting of black, argillaceous limestone and calcareous shale, were penetrated in the upper part of Altoba Clearwater No. 1 well. The remainder of the formation is well exposed immediately west of the well, where it is largely dark grey to black, fine-grained limestone in uniform beds a few inches to 2 feet or more thick. The strata contain several zones of ellipsoidal nodules of black, fine-grained, siliceous limestone that give the beds a rubbly appearance. The formation contains a Lower Mississippian fauna.

Rundle Formation

A complete section of the Rundle formation is exposed on the south side of Clearwater River about 1 mile east of Altoba Clearwater No. 1 well. The thickness was determined to be 702.7 feet. Details of this section are as follows:

Character of beds	Thickness Feet
Overlying beds—Rocky Mountain formation	
Soft, earthy, light blue-green shale	0.5
Very fine-grained, light grey limestone, slightly arenaceous; rose weathering at base	4.1
Bluish green, platy shale	15.6
Dense to fine-grained, light caramel brown limestone weathering earthy white	6.4
Fine-grained to dense, light grey, arenaceous limestone in a massive bed	5.3
Very finely banded, light grey, earthy, dolomitic limestone	1.8
Light grey, arenaceous limestone with small, irregular blebs of grey chert	13.0
Dense, light grey, somewhat porous limestone with many light grey chert nodules up to 1 inch across. Two feet of dense, very light brown dolomite near base. Basal foot is finely bedded, shaly marl with many irregularly shaped vugs	27.3
Cream colour weathering, finely bedded, very light grey dolomitic limestone	2.4

	Thickness Feet
Very light grey, fine-grained, somewhat porous limestone; pores clogged with pyrobituminous matter; a few thin chert beds and chert breccia in basal 3 feet	21.3
Very light grey, fine-grained limestone; lower 10 feet is highly porous and pores contain much pyrobituminous matter	18.6
Finely granular, light grey limestone with chert nodule beds up to 6 inches thick; rock has pin-point porosity	7.7
Massive bedded, very light grey, finely granular limestone with irregularly shaped vugs up to 2 feet across	14.0
Massive bedded, buff weathering, fine-grained, light grey limestone	56.0
Porous zone in dark grey, speckled limestone; much pyrobituminous residue in vugs	6.9
Coarse-grained, medium dark grey to brownish limestone in beds 4 to 10 feet thick	39.1
Very fine-grained, light grey, arenaceous limestone	11.0
Dense, black, platy limestone	34.0
Soft, earthy, light grey limestone breccia	9.0
Poorly exposed, largely fine-grained, light grey, silty limestone	140.0
Fine-grained, light grey, massive to platy limestone containing small, euhedral, quartz crystals	17.6
Dark grey, oolitic limestone in beds up to 2 feet thick	33.0
Massive to platy, fine-grained, dull black to dark grey limestone	31.2
Massive, white weathering, very coarse-grained, dark brownish grey limestone	9.6
Massive, light grey, coarse-grained limestone, some crinoid stems	32.0
Similar to above, but slightly darker and contains many fragments of fossils; grades into fine-grained, dull black limestone in basal 40 feet	145.3
Total thickness	702.7

Underlying beds—Banff formation

Rocky Mountain Formation

Ten to 12 feet of massively bedded, rose weathering, light grey, dolomiticquartzite overlies the Rundle formation in all sections examined. A 1-foot bed of very porous, black, quartzitic sandstone marks the base. It emits a strong odour of naphtha when struck with the hammer. Thin layers of chert-pebble conglomerate occur in the upper 3 feet of the formation. The formation rests upon the eroded surface of the Rundle formation.

Spray River Formation

The following section was measured on the south side of Clearwater River about a mile east of Altoba Clearwater No. 1 well.

Character of beds	Thickness Feet
Overlying beds—Fernie formation	
Fine-grained, black limestone in beds up to 1 foot thick	15.0
Dark grey to black, fine-grained limestone, weathering with a hackly surface; contains some black chert nodules	25.0
Uniform ½- to 1-inch beds of dark brown, fine-grained, argillaceous limestone; weathered surface has a banded appearance; grades downward into dark brown weathering, very thinly bedded, platy, shaly, bituminous limestone	21.5
Dull black, nodular, phosphatic limestone in uniform 1- to 1½-inch beds; weathers deep brown to maroon; basal bed (1 foot thick) is dark brown, earthy to shaly, arenaceous limestone	43.5
Total thickness	105
Underlying beds—Rocky Mountain formation	

The contact of this formation with underlying beds is sharp, but whether or not an erosional interval is represented could not be determined.

Fernie Formation

No complete section of the strata intervening between the Spray River formation and the basal Blairmore conglomerate has been found in this map-area. At several localities on both the east and west sides of Marble Mountain it has been possible, nevertheless, to determine fairly accurately that an average thickness of 200 feet of strata are present. Examination of several incomplete sections indicate that the succession consists of some 130 feet of black shales grading upward without observable break into thinly bedded sandstones and carbonaceous shales. A 4-foot bed of fine-grained, black, phosphatic limestone marks the base. It is very rich in fossils. This bed proved to be a very useful horizon marker. The overlying shales are poorly exposed, but those seen resemble the shales that characterize the greater part of the Fernie formation elsewhere. The sandstones that predominate in the upper 70 feet of the succession are in beds from 1 inch to 2 feet thick. They are fine-grained, dark grey, and finely crossbedded. The sandstone beds immediately above the black shales weather a rusty brown, whereas those at the top of the succession weather a light brown to buff. Nikanassin? A single 4-inch coal seam was observed 50 feet below the top in the best exposed section on the west flank of Clearwater anticline, just west of the western border of the map-area.

The contact with the underlying Spray River formation is sharp, but apparently conformable. The upper contact is considered to be erosional as the conglomerate at the base of the overlying Blairmore group fills shallow channels cut into the underlying strata.

The succession appears to be the product of continuous sedimentation in an environment gradually changing from marine to brackish, or even fresh-water, conditions. The strata are assigned to the Fernie formation, but it is possible that some Kootenay beds are present in the upper part. The fauna contained in the basal limestone is considered to be indicative of Lower Jurassic time, but it has certain Upper Triassic affinities. Fragments of belemnites are found in the black shales.

Blairmore Group

The most nearly complete section of the Blairmore group occurs on Tepee-Pole Creek on the west limb of Tepee-Pole anticline, where the beds are 1,275 to 1,300 feet thick. This is probably a minimum, for a comparison with other partial sections indicates that as much as 200 feet of the uppermost beds of the formation are absent in the Tepee-Pole section. Evidence that the east limb of the Tepee-Pole anticline is faulted is provided by the fact that a maximum of 1,100 feet of Blairmore strata are represented in it on Tepee-Pole Creek.

The lithological succession of the Blairmore series in this map-area is markedly similar to that in the Bow River region to the south. A massive, chert and quartzite pebble conglomerate 33 to 40 feet thick marks the base. It is overlain by progressively thinner bedded, coarse-grained, quartzitic sandstones and finely crossbedded, dark brown sandstones interbedded with brown, carbonaceous shales, locally bearing plant remains. Thin beds of dark brown weathering, dark grey, fine-grained limestone occur approximately 450 feet above the base. Strata above the limestone beds are typical of the upper part of the Blairmore in other regions to the south. Massive beds of coarse- and fine-grained, greenish grey, crossbedded sandstones alternate with light olive-green, locally maroon, crumbly shales. A massive chert-pebble conglomerate, similar to the basal conglomerate, except in its content of pebbles of igneous rock, occurs near the top of the formation. It is well exposed just south of Clearwater River in the northwest corner of the map-area, but was not observed in the Tepee-Pole sections.

Blackstone Formation

The Blackstone formation corresponds in lithology, stratigraphic position, and fossil faunas with the Lower Alberta formation in areas to the south. Best exposures in the map-area occur along Bread Creek south of the southern extension of Tepee-Pole anticline. There, as in other exposures, the rusty weathering, fissile, black, sandy shales that compose virtually the entire formation are involved in extremely complex folding. Consequently, no reliable figure for the thickness of the formation was obtained. Consideration of all available data indicates that the formation is between 800 and 1,050 feet thick. There is room for 1,050 feet of beds between the last observed Blairmore outcrop and the Bighorn beds exposed on Tepee-Pole Creek east of Tepee-Pole anticline, but the strata are folded and faulted and, consequently, the apparent thickness is undoubtedly greater than the true thickness.

Bighorn (Cardium) Formation

The general character of the Bighorn is similar throughout the area, and the formation seems to preserve a fairly uniform thickness of 235 to 260 feet. In detail, however, it presents marked variations in lithology within distances of a mile or less. It consists essentially of two shaly sandstone members, averaging 6 feet thick, separated by 225 to 250 feet of rusty weathering, nodular to fissile sandy shales. In different sections, however, the basal sandstone member may be so shaly as to be virtually indistinguishable from the overlying shale, or may be represented by two or more sandstone beds each 5 to 15 feet thick. Locally sandstone beds appear within the shaly, central part of the formation. Along James River a 2-foot bed of black chert-pebble conglomerate rests upon the ripple-marked surface of an underlying, buff weathering, brown, quartzitic sandstone that marks the top of the Bighorn formation. A similar

2-foot conglomerate bed rests upon the basal sandstone of the Bighorn. In sections where the basal member is represented by two sandstones, each may be capped by pebble conglomerate.

The sandstones and the shales are fossiliferous. The upper sandstone carries the characteristic form Cardium pauperculum Meek. Both sandstones and shales carry Scaphites ventricosus M. and H., Inoceramus cf. inconstans Woods, and I. umbonatus var. exogyroides M. and H. These latter fossils are also abundant in the lower part of the overlying Wapiabi formation, but do not occur in the Blackstone formation.

Wapiabi Formation

The Wapiabi formation is exposed in long, continuous sections along James and South James Rivers. Like the Blackstone formation, it is complexly folded and faulted and no reliable determination of the thickness has been obtained. By subdividing the formation into several lithological zones and studying many exposed incomplete sections, it was deduced that the formation is between 1,500 and 1,850 feet thick. Knowledge of these zones and their faunal characteristics is of the greatest aid in working out the complex structural conditions of the region. The lithology is indicated in the following generalized section.

	Thickness Feet
Upper concretionary shale and transition zone	440
Platy shale zone	650-900
Lower concretionary shale zone	400-500
Total thickness	1,490-1,840

Lower Concretionary Shale Zone. No undeformed section of this zone was observed. Its thickness is known to be greater than 400 feet and some evidence suggests that it is not much greater than 500 feet. The conglomerate described as overlying the upper sandstone of the Bighorn formation more properly belongs to the Wapiabi formation, as it is in sharp contact with the underlying sandstone but grades upward into dark grey, fissile shales interbedded with very thin ($\frac{1}{2}$ inch) beds of dark grey, fine-grained sandstone. Toward the top of the zone increasing numbers of small, brown, ironstone nodules appear. The nodules are embedded in shale beds separated at 6-inch to 2-foot intervals by sandstone beds ½ to 1 inch thick. The sandstones give the outcrop a characteristic banded appearance. The nodules at the top of the zone are individually larger than those below. They are irregularly distributed through the sandy shale and rarely form the definite bands characteristic of the upper concretionary shale zone. Nodules near the base have commonly a septarian structure.

The following fossil species[1] occur scattered through this zone, but are particularly abundant in the uppermost 50 feet:

Pleuromya sp.
Inoceramus umbonatus M. and H.
I. umbonatus var. *exogyroides* M. and H.
I. pontoni McLearn
I. cf. *selwyni* McLearn
I. cf. *inconstans* Woods
I. sp. indet.
Eutrophoceras sp.
Baculites codyensis Reeside
Scaphites ventricosus M. and H. (3 varieties)
S. vermiformis M. and H.

Baculites codyensis is apparently confined to the uppermost beds of this zone, where it is in association with a variety of *Scaphites ventricosus* with broad ventor and widely spaced ribs and *S. vermiformis*. *Eutrophoceras* sp. seems also to be confined to the upper part of the zone, but below the beds containing *B. codyensis*. The *Inoceramus* forms range through the zone and down into the underlying Bighorn formation.

Platy Shale Zone. This zone is exposed in faulted section on James River about 1½ miles east of its junction with Willson Creek. A complete and evidently unfaulted section is exposed on Willson Creek commencing about 1½ miles above the mouth. The zone is approximately 900 feet thick and consists predominantly of dark, thinly bedded, platy to fissile shale interbedded with layers of dark grey, fine-grained sandstone ½ inch to 1½ inches thick. The sandstone gives a distinctly banded appearance to outcrops. Large, light yellow, buff weathering nodules of fine-grained, dark brownish grey limestone occur locally in the central part of the zone. Two limestone beds, 1 to 2 feet thick,

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[1] Determinations are by F. H. McLearn, Geological Survey, Canada.

occur about 10 feet apart 350 feet below the top of the zone. They are reliable markers in the central and southwestern parts of the map-area.

Fossils are not plentiful in the platy zone. Scaphites ventricosus and S. vermiformis have been found at several horizons and a new species of Inoceramus, resembling I. pontoni but with strong ribbing, is common at the base.

Upper Concretionary Shale Zone. This zone is well exposed in three sections on James River in the vicinity of the mouth of Willson Creek and at the north end of Old Baldy Mountain. Its thickness and that of overlying transition beds is about 440 feet. The zone consists of grey weathering, sandy shale carrying ellipsoidal, orange to red weathering concretions in uniformly spaced layers parallel to the bedding. Baculites ovatus Say is common throughout the zone. Forms occurring in the underlying zones do not extend into this upper zone.

The transition beds between the marine Wapiabi and the non-marine Brazeau formation vary markedly in character in different parts of the area. In the central parts the upper 75-100 feet of the Wapiabi formation is a thinly bedded, dark grey shale containing irregularly scattered, yellow-buff weathering limestone concretions. Thin beds of grey sandstone in the shales increase in thickness to 4 feet or more toward the top, which is marked by a massive, greenish grey sandstone regarded as the basal sandstone of the Brazeau formation. The shales at the top are yellowish green, contain beds of bentonite, and locally exhibit thin layers with cone-in-cone structure. Farther west the sandstones are much more rusty weathering and a 2-foot bed of grey, quartzitic sandstone overlain by a single layer of minute, black, chert pebbles resembling large wheat grains either marks the contact or is only a few feet below it. The shales intervening between this conglomerate and the massive sandstone of the base of the Brazeau are drab olive-green similar to the shales that occur throughout the Brazeau formation. No fossils were obtained from the transition zone.

Brazeau (Belly River) Formation

The Brazeau formation is a succession of sandstones, shales, and beds of conglomerate. Four sections of the formation were examined on James River.

All were similar in general aspect, but each showed marked variations not only in number, stratigraphic position, and thickness of the sandstones, and position and thickness of the conglomerates, but also in the thickness of the formation as a whole. The thicknesses range from 1,080 feet just east of the confluence of the river and Willson Creek to about 1,500 feet on the west limb of Walton Creek anticline. The variation may be partly attributable to erosion of the Brazeau before the deposition of the Edmonton formation.

Most of the sandstones are massive, compact, medium to fine-grained, and grey-green. At the base and at the top of the formation the sandstones are virtually arkoses. They are very coarse-grained, highly feldspathic, strongly crossbedded, and weather light yellowish green. At many places the basal sandstones contain thin layers of black, light green, and grey, chert-pebble conglomerates. These conglomerates reach a maximum development on the top of Old Baldy Mountain where they form beds 10 or more feet thick. Farther west the conglomerate is represented only by a few scattered pebbles in the sandstone, and, locally, is absent. The shales are dark green to black, weather dark olive-green to brown, and break into angular fragments. They differ from shales of the Edmonton formation in that they are more uniform in colour, exhibit much less tendency to crumble in weathering, and are generally harder and more consolidated. Thin beds of dark brown, carbonaceous shale, generally less than 1 foot thick, are scattered through the formation, but no true coal has been observed. Bentonite is found in minor amounts in the lower part of the formation. It weathers a more pronounced yellow colour than that of the Edmonton and is in thinner beds, generally not over 4 inches thick.

The strata here placed in the Brazeau formation are lithologically similar to and occupy a similar stratigraphic position to the Brazeau formation in areas to the northwest. The formation is regarded as being the equivalent of the Belly River formation in Bearberry map-area to the east.

The contact of the Brazeau and Edmonton formations is placed at the base of a pebble, locally cobble, conglomerate, best exposed on James River and on Bread Creek in the vicinity of their confluence, and on James River ½ mile east of the mouth of Willson Creek. The conglomerate rests upon a channelled erosional surface. The magnitude of the hiatus represented is not known, but it is possible that part of the variations noted in the thickness of the Belly River may be attributed to erosion before the deposition of the Edmonton beds.

Edmonton Formation

The most nearly complete section of the Edmonton formation observed in the region extends down James River from the anticline near the eastern margin of the area eastward to the central part of the adjoining Bearberry map-area. Approximately 3,800 feet of strata are represented and evidence indicates that the entire Edmonton in this section does not greatly exceed 4,000 feet in thickness.

The Edmonton formation, like the Brazeau, consists of continental deposits of sandstones, shales, and conglomerate. The conglomerate at the base of the formation is generally not more than 2 feet thick and may be represented by a single layer of cobbles. On Bread Creek there are two conglomerates, each 2 feet thick and separated by 10 to 15 feet of coarse sandstone. The stones in the conglomerate range from $\frac{1}{4}$ inch to 3 or 4 inches in diameter. They represent quartzites, porphyritic igneous rock, dark limestone, and various coloured cherts. The conglomerate is similar to that described as marking the base of the Edmonton in the Wildcat Hills map-area[1] to the south. The sandstones are predominantly light grey, rarely greenish grey, coarse to fine-grained, and finely crossbedded. They occur in thicker beds than those of the Brazeau formation, are appreciably softer, and weather light grey to white. The light grey weathering sandstones contain appreciable amounts of bentonite, and in wet weather swell appreciably. The thinly bedded sandstones commonly weather light buff to reddish orange. Neither of these features is characteristic of the Brazeau sandstones in this area. The Edmonton sandstones are interbedded with crumbly shales ranging from dark olive-green to very light green. The latter type do not occur in the Brazeau formation. A black, fissile shale bed averaging 4 feet thick occurs between 400 and 600 feet above the base of the formation on James River and Tepee-Pole Creek. The locations of observed outcrops of the shale

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[1]Hume, G. S.: The West Half of Wildcat Hills Map-area, Alberta; Geol. Surv., Canada, Mem. 188, p. 6 (1936).

are indicated on the accompanying map. The strata of the Edmonton differ further from Brazeau beds in containing thin coal seams and in the much greater abundance of bentonite, which commonly forms beds up to 2 feet thick. Dinosaur bones and fossil tree trunks are much more common in the Edmonton than in the Brazeau. Chert-pebble conglomerate is confined largely to the base of the Edmonton, but shale fragment conglomerates occur at several horizons throughout the formation.

Despite the differences pointed out between the strata assigned to the Brazeau and to the Edmonton much difficulty is experienced in allocating isolated sandstone outcrops to one or the other formation. Certain sandstones of the lower part of the Edmonton are indistinguishable from beds in the Brazeau. Consequently, in the southeastern part of the map-area, where the widely scattered outcrops are largely sandstone, boundaries between the Brazeau and Edmonton are approximations at best.

Persons contemplating investigations in the area are strongly advised to examine the James River sections before continuing into the areas where outcrops are scattered.

Paskapoo Formation

The existence of Paskapoo strata beneath the drift in the northeast corner of the map-area is inferred from the distribution of the formation in Bearberry map-area, adjoining to the east. The presence of the formation at the southern border of the area is known from a few scattered outcrops of yellowish brown weathering, finely crossbedded sandstone exposed under upturned trees. The sandstones are lithologically similar to beds in the James River section of the Paskapoo in Bearberry area, but do not resemble beds in either the Brazeau or Edmonton formation.

On James River in Bearberry area crossbedded, coarse-grained, light tan to brown sandstones form massive beds at the base of the formation and are reflected topographically in a range of prominent hills. The contact of these sandstones with the underlying Edmonton formation is sharp on James River, where it is marked by an erosional surface. The beds overlying the basal sandstones form a succession of thinly bedded, brown sandstones, which weather light brown, with fine crossbedding prominently displayed on both weathered and fresh surfaces. They alternate with crumbly, light brown, yellowish brown, and brownish green shales and dark brown, carbonaceous shales. Thin lenses of coal are common, but do not form seams extending over any appreciable area. More than 3,000 feet, and possibly as much as 5,000 feet, of strata are present in the James River section.

STRUCTURE AND ECONOMIC POSSIBILITIES

All strata within the area are involved in complex folding and faulting. It is probable that the structure is even more complicated than indicated on the accompanying map, as in many critical areas little or no geological information is available.

The area may be divided conveniently into four major structural units: the Clearwater River folds; the Walton Creek anticline; the James River anticline; and the Great West syncline. All the anticlinal structures are possible sources of petroleum and natural gas.

Clearwater River Folds

A series of folds together forming an anticlinorium is observable in Palaeozoic strata exposed along Clearwater River in and to the northwest of the northwest corner of the map-area. Two distinct folds are observable within the map-area. The more easterly fold, named the Tepee-Pole anticline, extends southward from Clearwater River through Marble Mountain and across Tepee-Pole Creek. The Rundle formation and the greater part of the underlying Banff formation are exposed in the core of the fold, which plunges rapidly south from Marble Mountain and is known to plunge northward from Clearwater River. It is distinctly asymmetrical in cross-section (See cross-section A-B), with the east limb vertical and locally overturned to the east as much as 30 degrees from the vertical.

Fairly conclusive evidence has been obtained indicating the presence of one or more thrust faults resulting in considerable displacement along the eastern margin of this structure. The actual faults have not been observed, but are indicated by the fact that there is not room enough for complete sections of Blairmore, Blackstone, and Wapiabi formations in the valley to the east of the fold.

The Tepee-Pole anticline is connected with the Clearwater anticline on the west by a tightly compressed, but unfaulted, syncline. The Clearwater anticline plunges southward within this area and the Rundle formation disappears under a cover of overlying Mesozoic strata about 2 miles north of the most southerly exposure of Palaeozoic strata in Tepee-Pole anticline. Northwestward from the map-area, however, the Clearwater anticline forms a larger and more extensive structure than the Tepee-Pole anticline. Much the greater part of these structures lies beyond the limits of the map-area. Their northern extension has not been studied by the writer and the amount of closure on the top of the Devonian in either the Tepee-Pole or Clearwater anticlines is not known. The southern extension of these structures across James River is obscured by much low-angle thrusting and complex folding in the Blackstone, Bighorn, and Wapiabi formations. The James River section indicates, however, that one or more anticlinal structures cross the river and pass under a thrust plate of Brazeau strata farther south.

Search for oil in these structures should be confined to the basal part of the Banff and the underlying Devonian and older formations, as all strata above the lower part of the Banff formation are exposed in the cores of the folds. No drilling has been done on the Tepee-Pole anticline, but one well, Altoba Clearwater No. 1 well, was drilled through the Devonian on Clearwater anticline on the south side of Clearwater River about 1 mile west of the west boundary of the map-area. The grey dolomite forming the upper part of the Devonian shows scattered pinpoint porosity, but no thick porous zones. The greatest porosity observed was in the light grey, coarse-grained dolomite encountered at drilling depths between 1,185 and 1,284 feet. Some gas and oil showings were encountered in drilling this well, the most notable being in the above-mentioned light grey dolomite. No encouraging indications were reported from the pre-Devonian strata penetrated below 2,721 feet in the well.

The low gas pressure noted in this well is also characteristic of wells drilled on Moose Mountain dome south of Bow River, a similar fold with an exposed Palaeozoic limestone core. This condition has led the writer to the conclusion that where limestone folds are not covered by thick layers of impervious strata such as shale, pressures will be low because of dissipation of the gas at the surface through fractures in the brittle limestone.

Walton Creek Anticline

This anticline extends into the southwest corner of Bearberry map-area to the east where it was referred to as the Stafne Ridge anticline. It has been traced northward from Walton Creek across James River to Tepee-Pole Creek. The plunge of the structure north of Walton Creek is northward. South of the creek it plunges southward to Red Deer River. The structure has a minimum length along the axis of 18½ miles and a vertical closure on the top of the Wapiabi formation exceeding 1,000 feet. The uppermost beds of the Wapiabi formation are exposed in the core of the structure on Walton Creek in Bearberry map-area and are believed to be present in the swampy valley northward along the axis in Marble Mountain area.

The structure is asymmetrical in cross-section. The west limb dips westward at angles varying from 20 to 55 degrees. The strata are duplicated by several westerly dipping thrust faults. The east limb stands at angles near the vertical. Much thrust faulting of the east limb is observable on James River and Tepee-Pole Creek. This zone of faulting probably extends parallel to the east limb of the structure southward at least as far as Red Deer River. The complex deformation of the east limb is further complicated by an easterly dipping fault. Where observed on Tepee-Pole Creek and James River, however, it appears to have only a small displacement.

The value of this structure as a possible source of oil and gas would seem to depend largely on whether or not the Rundle formation is present in the core of the fold. Examination of outcrops of this formation to the west indicates that the upper part contains zones with excellent porosity and permeability and contains much pyrobituminous residue, indicative of the past existence of petroleum. It is from this horizon that the present crude oil production at Turner Valley is obtained.

If the zone of faulting bordering the east side of the structure maintains a high angle of dip to depth then Rundle strata can be expected to occur in the core of the anticline, but if the fault zone dips westward at angles approaching 45 degrees no limestone will be present in the core of the fold. Only drilling can determine which condition prevails. As the axial plane of the fold dips westward at an angle of about 45 degrees, the structure should be tested from drilling sites located between half a mile and a mile west of the surface trace of the axis.

James River Anticline

An anticline plunging gently southward was observed on James River, with its axis approximately 1 mile west of the eastern boundary of the map-area. The region both north and south of this is drift covered and no information was obtained regarding the extent of the structure. The axis of the Monarch anticline occurring in Edmonton strata on Red Deer River in the northern part of Fallentimber (west half) map-area appears to be in line with that of the James River anticline. It is probable that the two anticlines are parts of the same fold.

The east limb of the structure as exposed on James River in Bearberry map-area is an apparently unbroken succession of Edmonton strata dipping eastward as far as the Edmonton-Paskapoo contact. At the contact some isoclinal folding is observed.

The west limb of the anticline, as exposed on James River, is so intensely folded that it has not been possible to gain any reliable estimate of the amount of doming of any one bed represented in the river section.

Petroleum Structures No. 1 well (l.s. 4, sec. 2, tp. 33, rge. 7), drilled to an approximate depth of 5,210 feet, is located just east of a line joining James River and the Monarch anticline. This well drilled an uninterrupted section of Edmonton and Brazeau strata down to 2,830 feet and Wapiabi shales to 4,620 feet, where a fault was encountered and Brazeau strata were repeated. Neither the direction nor degree of inclination of the plane of this fault is known. A zone of isoclinal folding observed on James River in sec. 5, tp. 34, rge. 7, may be the surface indication of this fault, and indeed is the only point along the river section where there would seem to be room for such a fault. If such be the case, it is probable that the fault would be encountered at 4,500 to 5,000 feet beneath the James River fold, but because of the known southern plunge of the fold the fault should occur at a lower stratigraphic horizon than at the site of the Petroleum Structures No. 1 well. That the fold includes Rundle strata above the fault at this latitude is most questionable, but the possibilities of its occurrence in the core would seem to increase farther north along the fold. Unfortunately, the northern extension of the fold is almost entirely covered by glacial deposits, and its character could not be determined.

A line of springs was observed extending from sec. 31, tp. 34, rge. 7, to sec. 15, tp. 33, rge. 7, in Bearberry map-area. Although these springs may mark the presence of an impervious bed in the Edmonton formation, the possibility that they mark the surface trace of a fault separating the James River anticline from the northern extension of the Monarch anticline cannot be entirely neglected.

Great West Syncline

The northern end of a broad syncline extends into the southwestern part of Marble Mountain map-area. Paskapoo strata occupy the central part of the syncline within the area, and successively older strata down to the Wapiabi formation extend outward to the periphery of the structure. The syncline has the appearance of having been deformed by earth stresses acting in a northeasterly direction, resulting in much duplication of the strata forming the northeastern margin of the structure. In addition, the structure has been displaced along low-angle thrust faults to such an extent that its eastern margin rests upon the southern extension of the Clearwater River folds. Structural conditions within this broad syncline are not favourable for the accumulation of petroleum or natural gas.

Coal

Thin seams of coal suitable for domestic use have been observed in the Edmonton formation at several points on James River east of the Walton Creek anticline, and on Tepee-Pole Creek from the mouth up to the point where it turns westward. These seams do not exceed 1 foot in thickness and as such cannot be classed as commercial seams.